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Preliminary Lumber Recovery for Dead and Live Engelmann Spruce

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Reference Abstract

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Lumber recovery, lumber grade distribution, and log values are presented for logs cut from dead and live Engelmann spruce (Picea engelmannii Parry ex Engelm.) trees. The dead sample includes standing and down trees killed by the Engelmann spruce beetle (Dendroctonus ruffipennis Kirby) over 20 years ago. 4

Keywords: Lumber recovery, lumber grading, log values, dead timber, Engelmann spruce (dead), Engelmann spruce, Picea engelmannii.

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Introduction

Stands of Engelmann spruce (Picea engelmannii Parry ex Engelm.) periodically experience high mortality due to infestations of the Engelmann spruce beetle Dendroctonus rufipennis (Kirby). In western Colorado, a large beetle population developed in windthrown timber in 1939 and spread to adjacent stands. A major epidemic resulted, killing an estimated 3.8 billion board feet of spruce by 1952 (Hinds et al. 1965).

The outbreak left large volumes of dead spruce, both standing and down, in various stages of deterioration. Research has shown this resource to be suitable as a raw material in particleboard (Mueller 1959), for pulp (Lowery et al. 1977), and for house logs (Western Timber Industry 1974).

Recently, the lumber industry in the Rocky Mountain region has begun to harvest Engelmann spruce killed by insects over 20 years ago. With the exception of a study by Keepf (1978), lumber recovery information is limited to live trees (Henley and Plank 1974, Mueller and Barger 1963). This study was conducted in cooperation with Kaibab Industries and the USDA Forest Service, Rocky Mountain Region to provide additional lumber recovery information on dead Engelmann spruce. This research note presents preliminary lumber recovery information on the short or mill length logs.

Methods

Field and Mill Procedures

Forest Service and industry representatives examined several stands of dead spruce in the White River National Forest of Colorado. Three stands were selected to include the range of quality and size of Engelmann spruce that exists in western Colorado. Within each stand, both standing and windthrown dead trees were selected. These two categories are not separated for this preliminary report. A total of 296 dead trees were selected. Forty-nine live trees were also selected from a single stand to compare the relative drop in product recovery and value the dead timber incurred.

Study trees were felled and bucked into woods-length logs. Logs down to a small-end diameter of 6 inches inside bark, and 8 feet long were included in the study. Log identity was maintained so the recovery data could be related back to trees. Woods-length logs were bucked into mill-length logs, then scaled by Forest Service scalers applying Scribner scaling rules[2/]. Gross cubic log volume was estimated by using Scribner scale length and

[2/]Scale taken in accordance with USDA Forest Service Handbook rules.

diameter measurements and Smalian's formula[3] for all logs except the butts. Butt log volume was estimated by Bruce's equation (Bruce 1970).

Mill equipment included a ring debarker, single cut band saw, horizontal resaw, and a two-saw edger. All lumber was identified back to the individual log from which it was sawn. The lumber was kiln dried, planed S4S, and graded under the supervision of a Western Wood Products Association (WWPA) grading inspector. Recovery data are based on the grade and volume of lumber in a surfaced dry condition. The mill manufactured primarily random length dimension lumber.

Lumber prices used to calculate log values were based on 1978 Engelmann spruce prices for boards and 1978 white wood prices for dimension grades (Western Wood Products Association 1979).

Data Analysis

Three variables used to describe lumber yield results are cubic-recovery percent, dollars per thousand board foot lumber tally, and dollars per hundred cubic feet of gross log volume. Definitions of these variables appear below:

Cubic-recovery percent: The cubic volume of lumber recovered from the log, expressed as a percent of gross log volume.

Dollars per thousand board foot lumber tally: ($/MLT) The dollar or unit value of the lumber produced per thousand board feet of lumber tally.

Dollars per hundred cubic feet of log volume: ($/CCF) The dollar value of the lumber per one hundred cubic feet of gross log volume. It is the unit value of the log.

Cubic-recovery percent and $/CCF were regressed over log diameter to analyze differences between live and dead logs. Several curve forms were tried using cubic-recovery percent and $/CCF as dependent variables and selected transformations of log diameter as independent variables. For both of these dependent variables, the general curve form, $y=b_0+b_1D+b_2/D+b_3/D^2$ consistently had the highest coefficient of determination and lowest standard deviations from the regression. This occurred in both the live and dead sample analysis. In this equation, y is either cubic-recovery percent or $/CCF, b_0--b_3 are regression coefficients, and D is small-end diameter of the log.

[3] Smalian's formula--Volume in cubic feet = $0.002727\ L\ (D_S^2 + D_L^2)$ where:

L = log length in feet
D_S = small-end diameter
D_L = large-end diameter.

Similar curve forms have been used to represent lumber yield results by Fahey (1974) and Snellgrove and Cahill (1980).

Covariance analysis was used to determine if the data supported fitting separate coefficients for live and dead logs. Coefficients were significantly different[4/] for live and dead logs so separate models were used.

There was no significant relationship between $/MLT and log diameter for the live logs. A highly significant relationship between log diameter and $/MLT exists in the dead sample; however, the amount of variation accounted for by diameter is small. With this in mind, I chose to present the average $/MLT for the live and dead sample.

Results and Discussion

Inferences drawn from these study results are subject to limitations. It should be remembered that the trees are representative of western Colorado and the recovery is based on processing in a random length, dimension mill. Any wider application of the results should take these factors into consideration.

Lumber Grade Yields

Figure 1 shows the lumber grade distribution for the live and dead sample. It is evident that lumber quality differences exist between live and dead logs. Only 24 percent of the lumber produced from dead logs was of Standard and Better grades as compared to 72 percent for the live sample.

Difference in the lumber quality produced from live and dead logs can be reflected by average lumber values ($/MLT). When current prices were applied to the lumber, the average dollars per thousand board-foot lumber tally was $143 and $198 for the dead and live respectively. This difference in average lumber values is statistically highly significant. The 95-percent confidence interval for these averages was ±$1.80 for the dead logs, and ±$3.48 for the live logs.

It is my observation that the lumber grade loss was primarily due to the presence of weather checks in dead logs that showed up as splits in the lumber. Splits are a degrading factor when present in dimension lumber. For instance, to meet the Standard (No. 2) grade, splits no greater in length than 1-1/2 times the width of the piece are allowed. Utility (No. 3) grade, however, is less restrictive and allows splits up to 1/6 the length of the piece (Western Wood Products Association 1977).

[4/] Probability level 0.01.

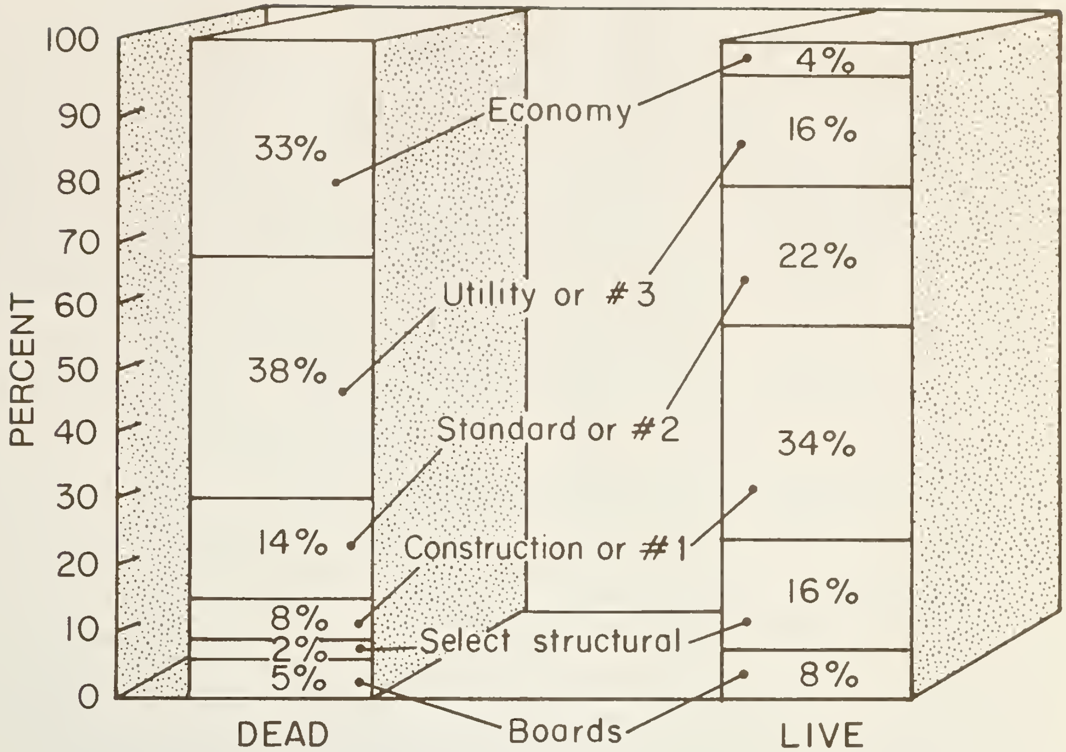

Figure 1.--Lumber grade yield as a percent of total lumber tally volume for logs cut from dead and live Engelmann spruce trees.

Blue stain was present in all the dead logs but is not a limiting factor in grading dimension lumber. If all other grade criteria are met, a heavily stained dimension item can still meet Standard (No. 2) grade requirements.

Lumber Volume Loss

In addition to lower value lumber, the dead logs produced less lumber per unit of log volume. This is evident in figure 2 which shows a wide separation between the dead and live cubic-recovery curves. The cubic lumber volume was calculated by applying rough green board sizes to the board-foot shipping tally. Cubic log volume is the gross log volume with no deductions made for defects.

Cubic-recovery differences were also related to the presence of checks. Severely checked lumber often fell apart during handling in the sawmill, or showed up as cull boards in the planer.

Live logs: % = 1.395 − .022D − 7.824 1/D + 14.965 $1/D^2$
Dead logs: % = 2.007 − .042D − 15.824 1/D + 44.055 $1/D^2$

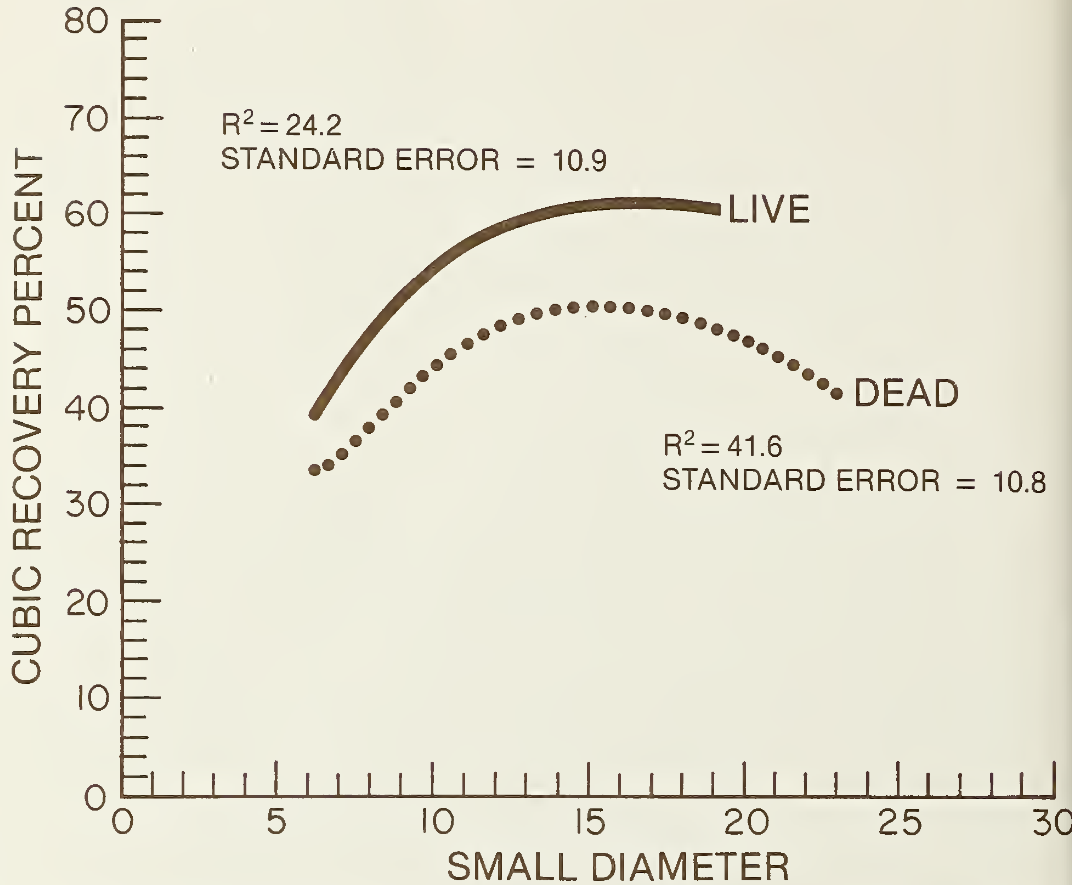

Figure 2.--Cubic-recovery percents curved over small diameter for log cut from live and dead Engelmann spruce trees.

The cubic-recovery for the dead logs increased with diameter up to about 15 inches, and then dropped off steadily. Beyond 15 inches, log defects in the form of sap decay and butt rots tended to decrease the cubic recovery. Butt rot was often noticed in the larger windthrown trees, as this type of defect predisposes them to wind damage. Sap decay was usually found at the base of both standing and windthrown dead trees. Here, moisture and temperature conditions are favorable to fungal growth. The majority of loss caused by sap decay is left in the woods as long butts, however the faller is more apt to long butt smaller trees with sap decay than larger trees.

A slight trend of decreasing cubic-recovery percents were seen in the live logs greater than 18 inches. Although the logs beyond this point were defect-free they were highly tapered butt cuts. High taper in saw logs has been shown to decrease cubic recovery (Dobie 1964, Hallock et al. 1979).

Recovery information for live and dead timber may be presented on a net log scale basis, obtained by reducing gross log scale volume for defects thought to limit lumber yields. For dead timber, however, the net Scribner short log scale available for this report is limited in its use. Scalers' rules require over-deduction for the presence of checks which result in many cull logs and logs with no net scale. Because of this, recovery information for dead timber based on net Scribner scale is of limited value.

Tables 1 and 2 present lumber recovery and log values by 1-inch diameter classes for the dead and live samples.

Total Dollar Loss in Dead Logs

Total dollar loss in dead logs results from a combination of lumber grade ($/MLT) and lumber volume (cubic recovery) losses. An accurate way of accounting for both losses is $/CCF, shown regressed over diameter in figure 3.

The $/CCF curves follow a similar pattern seen in the cubic recovery curves in that log value increased through the smaller diameters and dropped off in the larger diameters. This was to be expected since there was little relationship between average $/MLT and log diameter.

Based on the overall sample means, there was a 39-percent decrease in the value of dead logs compared to live logs. An important point to consider is that the 39 percent does not take into account any differences in logging and manufacturing costs between dead and live timber. A better understanding of the potential value in processing dead Engelmann spruce logs will be gained if this information becomes available.

Additional Analyses Planned

The preliminary results presented in this report are an important step toward a better understanding of the resource potential of dead Engelmann spruce. Maximizing utilization of this resource, however, will be enhanced by further defining some of the problems associated with its use. For instance, straight checks may not reduce lumber grade yields and lumber recovery as much as spiral checks. Spiral checks may hamper any adjustment made by the sawyer or edgerman to confine the check to a narrow single piece. The relationship between check spirality and lumber volume and value recovery will be investigated in future analysis.

Table 1.--Log scale, lumber tally, log value, and cubic volumes by scaling diameter for logs cut from dead Engelmann spruce trees

Log scaling diameter	Number of logs	Log scale[1]/ Gross	Log scale[1]/ Net	Lumber tally	Total value	Unit value	Volume: Log volume[2]/	Volume: Lumber volume[3]/	Volume: Sawdust volume	Volume: Residual
Inches		- - -Board feet- - -			Dollars	$/MLT	- - - - - - - -Cubic feet- - - - - - -			
5	8	65	0	128	18.09	141.33	24.68	9.41	1.50	13.77
6	149	1,775	655	2,599	360.60	138.75	538.16	188.18	28.30	321.68
7	71	1,465	560	1,714	240.53	140.33	331.89	123.50	17.68	190.71
8	115	2,640	1,040	3,760	543.95	144.67	715.88	269.83	37.00	409.05
9	112	3,750	1,810	5,053	728.91	144.25	885.70	362.97	50.59	472.14
10	94	4,850	2,470	6,107	949.24	155.43	960.65	439.80	62.66	458.19
11	83	5,130	2,400	6,740	1,047.58	155.43	1,021.79	486.69	68.66	466.44
12	77	5,620	2,850	7,881	1,180.92	149.84	1,154.08	572.21	73.75	508.12
13	72	6,630	3,350	8,670	1,294.29	149.28	1,281.20	628.97	78.38	573.85
14	45	4,660	2,140	5,965	879.26	147.40	883.36	431.86	54.42	397.08
15	53	6,870	3,300	8,276	1,251.46	151.22	1,202.35	593.92	76.46	531.97
16	43	6,640	3,320	7,864	1,159.21	147.41	1,131.95	562.76	71.93	497.26
17	28	4,930	2,470	5,566	799.44	143.63	855.70	398.20	51.30	406.20
18	21	4,160	2,240	4,437	646.30	145.66	662.42	317.29	40.60	304.53
19	17	3,950	1,690	4,234	607.97	143.59	627.99	302.62	38.45	286.92
20	15	4,030	1,460	3,977	557.67	140.22	626.47	284.08	36.03	306.36
21	7	1,920	680	1,952	276.30	141.55	298.76	139.38	17.61	141.77
22	6	2,040	1,150	2,073	301.23	145.31	320.36	148.11	18.69	153.56
23	1	380	230	304	34.34	112.96	57.11	21.62	2.72	32.77
24	5	2,060	690	1,927	267.44	138.79	328.49	137.47	17.37	173.65
25	0									
26	1	500	330	607	107.81	177.61	72.92	43.46	5.69	23.77
Total or average	1,023	74,065	34,835	89,834	$13,252.54	$147.52	13,981.91	6,462.33	849.79	6,669.79

1/ Log scale based on Scribner short log; USDA Forest Service Scaling Handbook rules applied.

2/ Cubic volume based on gross log volume.

3/ Cubic lumber volume based on a shipping tally with rough green dimensions applied to the lumber.

Table 2.--Log scale, lumber tally, log value, and cubic volumes by scaling diameter for logs cut from live Engelmann spruce trees

Log scaling diameter	Number of logs	Log scale[1/] Gross	Log scale[1/] Net	Lumber tally	Total value	Unit value	Volume: Log volume[2/]	Volume: Lumber volume[3/]	Volume: Sawdust volume	Volume: Residual
Inches		- - -Board feet- - -			Dollars	$/MLT	- - - - - - -Cubic feet- - - - - - -			
5	6	35	0	53	10.90	205.66	13.74	3.82	0.59	9.33
6	36	465	425	773	157.33	203.53	143.90	56.37	8.70	78.83
7	8	170	140	179	37.23	207.99	32.93	12.79	1.86	18.28
8	23	550	490	999	192.54	192.73	141.62	71.68	9.87	60.07
9	22	720	650	1,030	206.50	200.49	163.30	74.33	10.63	78.34
10	17	940	800	1,316	258.33	196.30	184.20	94.79	14.07	75.34
11	12	760	730	1,128	236.40	209.57	139.72	81.51	11.56	46.65
12	19	1,440	1,360	2,307	465.05	201.58	285.51	167.56	21.78	96.17
13	13	1,300	1,300	1,998	403.71	202.06	233.84	145.54	18.41	69.89
14	12	1,320	1,300	2,130	415.72	195.17	246.27	153.94	19.84	72.49
15	10	1,450	1,410	1,969	398.67	202.47	244.02	141.24	19.04	83.74
16	8	1,300	1,270	1,796	343.96	191.51	212.53	128.27	16.71	67.55
17	6	1,110	1,050	1,551	311.69	200.96	180.50	111.19	14.51	54.80
18	6	1,300	1,270	1,746	335.53	192.17	205.74	125.13	16.05	64.56
19	2	500	500	636	127.70	200.79	88.11	45.32	5.85	36.94
20	2	560	560	699	122.81	175.69	91.31	50.16	6.41	34.74
21	2	600	600	767	155.80	203.13	87.61	54.95	6.93	25.73
22	1	330	330	399	75.25	188.60	52.69	28.46	3.67	20.56
Total or average	205	14,850	14,185	21,476	$4,255.12	$198.13	2,747.54	1,547.05	206.48	994.01

1/ Log scale based on Scribner short log; USDA Forest Service Scaling Handbook rules applied.

2/ Cubic log volume based on gross log volume.

3/ Cubic lumber volume based on a shipping tally with rough green dimensions applied to the lumber.

Also, expanding the results by combining mill-length logs into woods-length logs and finally into trees will provide additional information to both resource manager and timber purchasers. Recovery data based on long logs is important since logs are bought and sold in this form. Tree information will reflect all the volume losses incurred when processing dead Engelmann spruce, including breakage and sap decayed volumes left in the woods.

Finally, log recovery and log value data will be presented on a net cubic-foot basis, after deductions have been made for log defects. The Forest Service and industry are evaluating alternative methods to the current use of Scribner log scale. Measuring log volumes in cubic feet is a possibility, and these data should be useful in this evaluation.

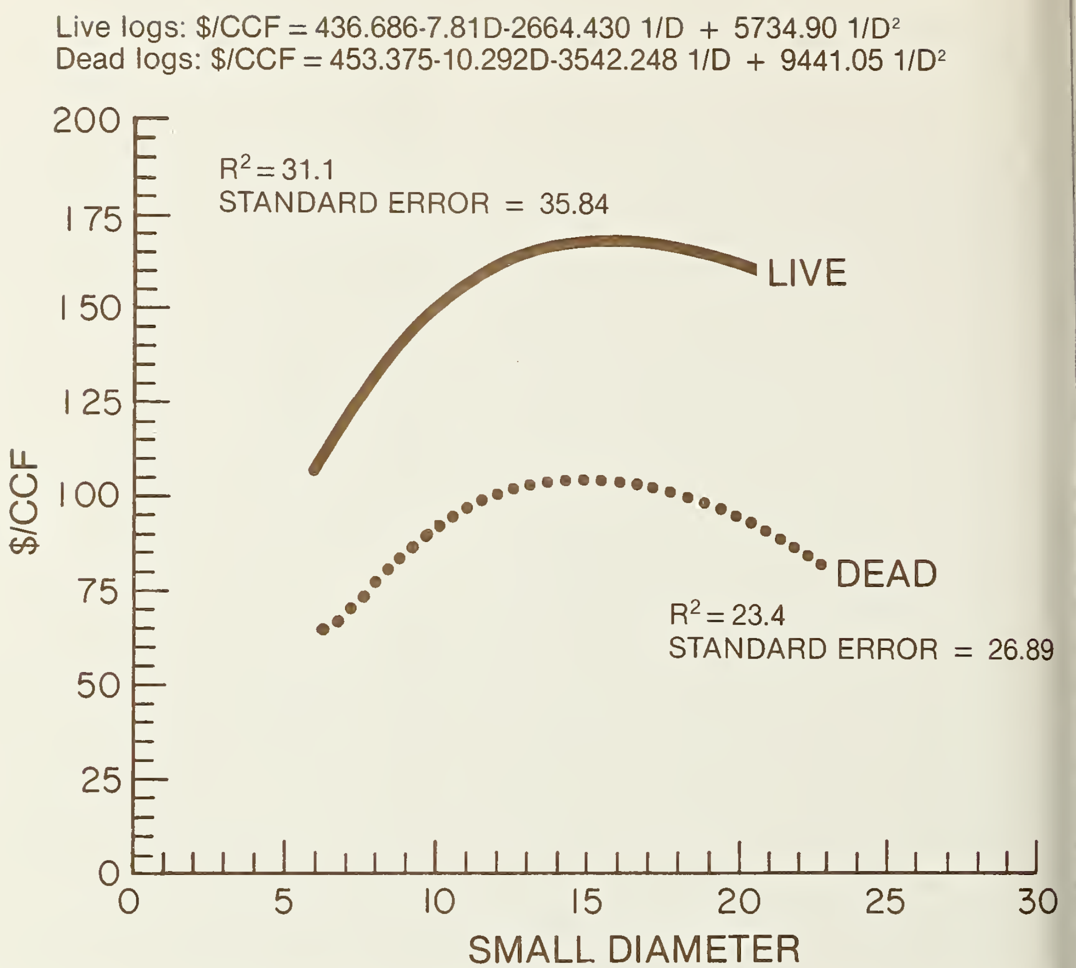

Figure 3.--Dollars per hundred cubic feet of log input volume curved over small diameter for logs cut from live and dead Engelmann spruce trees.

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